The Siberian Snake

Kai Hock

Liverpool Group Meeting, 12 August 2008

Overview

- The EPAC paper to review
- Spin polarisation
- Spin resonance
- What is a Siberian snake
- The paper: Optimising the snakes

EPAC08 paper - THPC023

OPTIMIZATION OF THE AGS SUPER-CONDUCTING HELICAL PARTIAL SNAKE STRENGTH*

F.Lin, H.Huang, A.U.Luccio, T.Roser
Brookhaven National Laboratory, Upton, NY, 11973, USA

Abstract

Two helical partial snakes, one super-conducting (a.k.a cold snake) and one normal conducting (a.k.a warm snake), have preserved the polarization of proton beam up to 65% in the Brookhaven Alternating Gradient Synchrotron (AGS) at the extraction energy from 85% at injection. In order to overcome spin resonances, stronger partial snakes would be required. However, the stronger the partial snake, the more the stable spin direction tilted producing

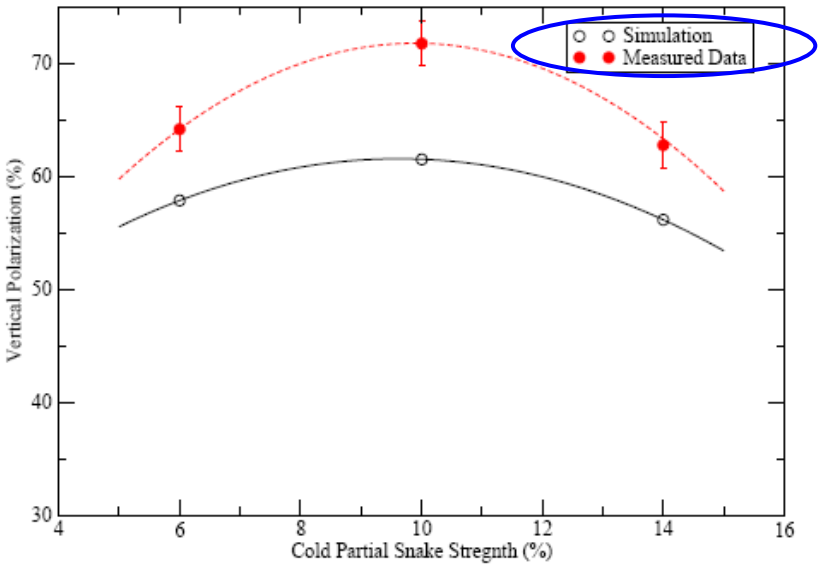
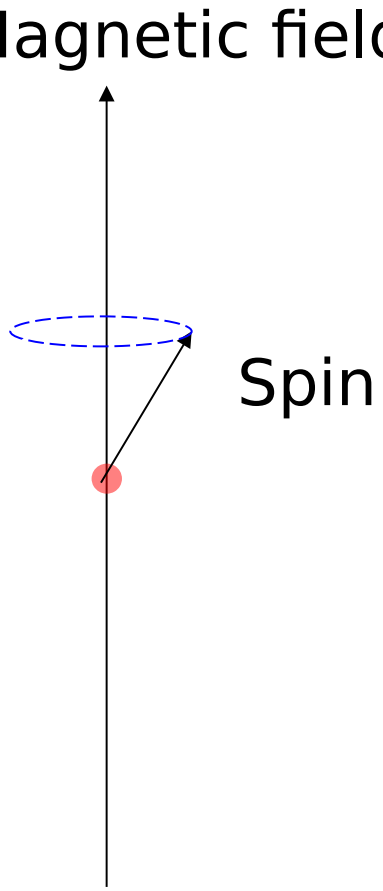


Figure 3: The polarization as function of the strength of cold snake. The solid line comes from the simulation and the dash line from the experiment.

Spin polarisation

Dr Desmond Barber, DESY



A proton or electron has
a magnetic moment called spin

This causes it to precess
about a magnetic field.

The field maintains the spin
direction - or polarisation.

At Brookhaven

Mei Bai's 423rd Brookhaven Lecture

In the AGS

Polarised protons are injected at 1.5 GeV.

They are accelerated to 25 GeV for RHIC.

Polarisation must be maintained. Problem is ...

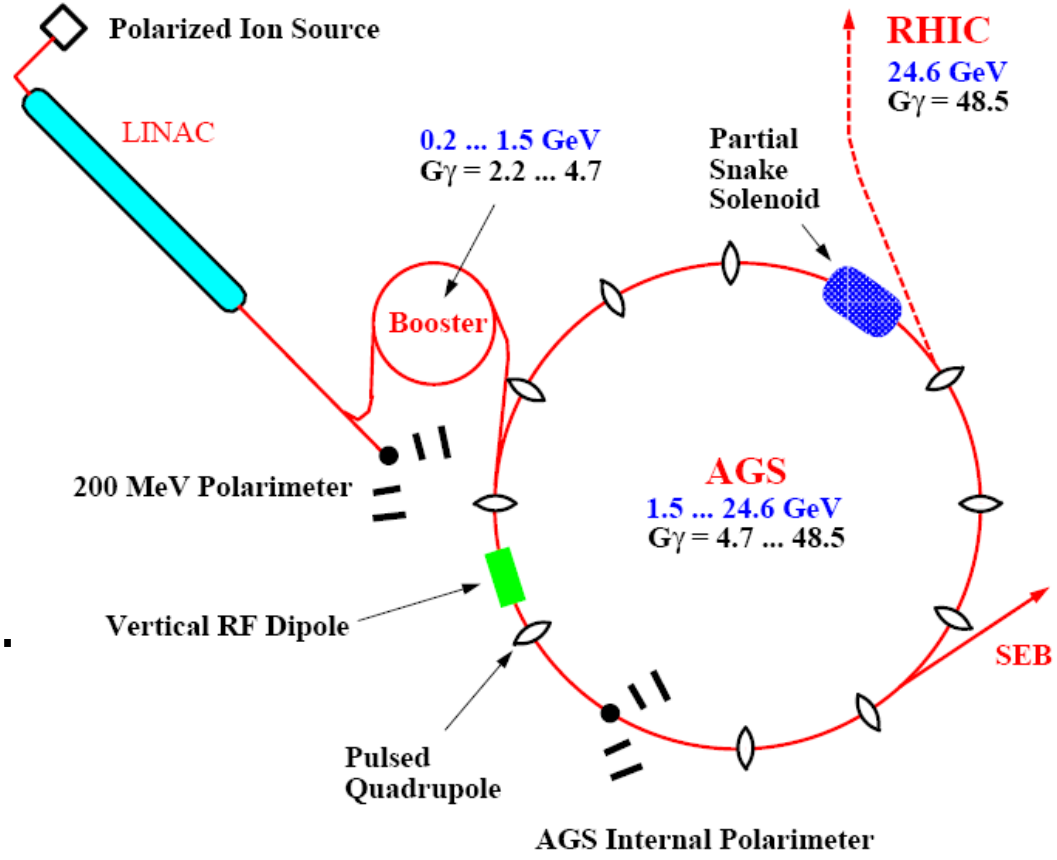


Figure 2.1: Schematic of the AGS complex for polarized proton acceleration.

Design Manual
Polarized Proton Collider at RHIC
1998

Spin resonance

he proton precesses as it revolves around the ring.

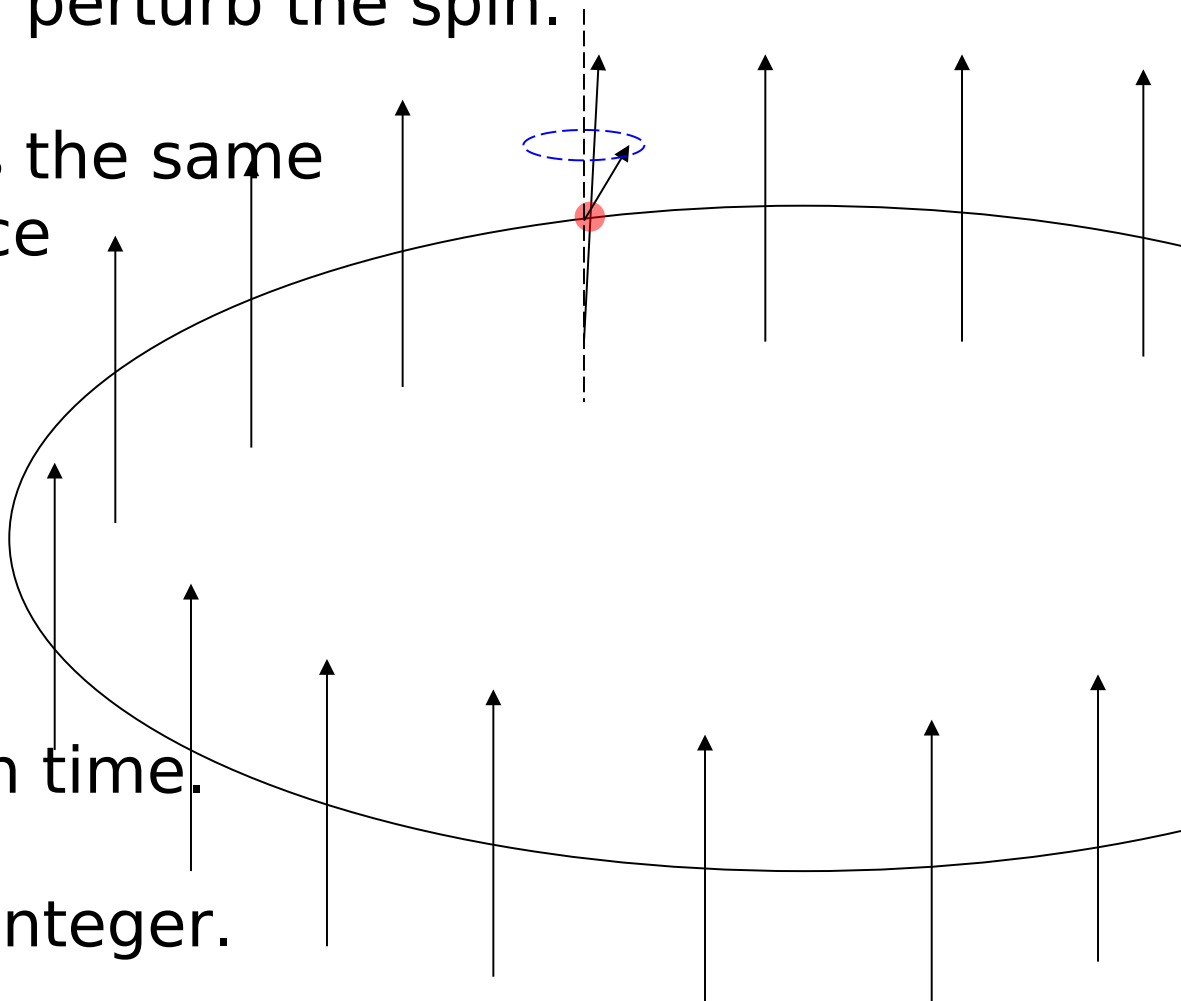
misaligned magnet can perturb the spin.

the precession phase is the same
ch time, the disturbance
ilds up.

his is spin resonance.

can happen if the
volution time is a
ultiple of the precession time.

e. if the spin tune is an integer.



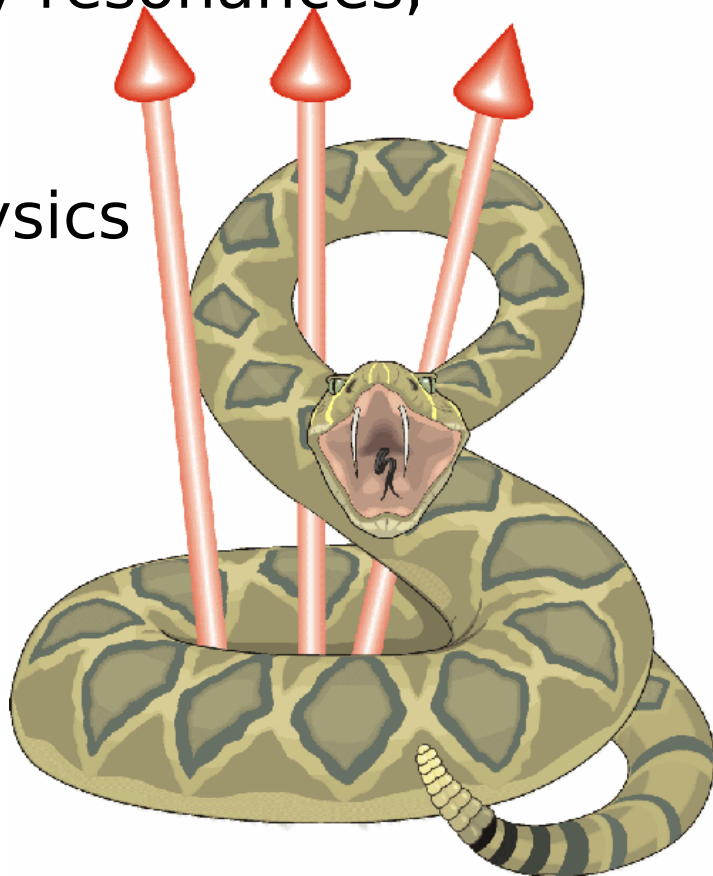
The Siberian snake

uring acceleration, the revolution time changes.
will go through many multiples of the precession time.

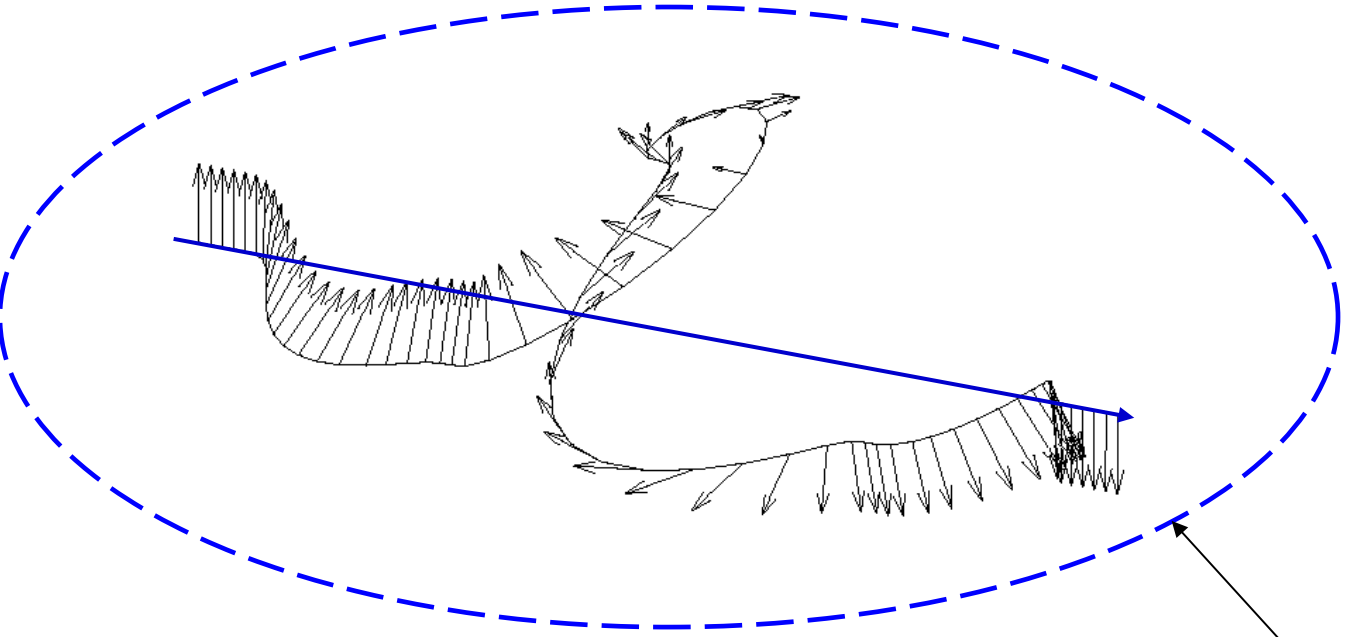
herefore the spin will go through many resonances,
nd ends up completely depolarised.

his is not good for the high energy physics
xperiments in RHIC.

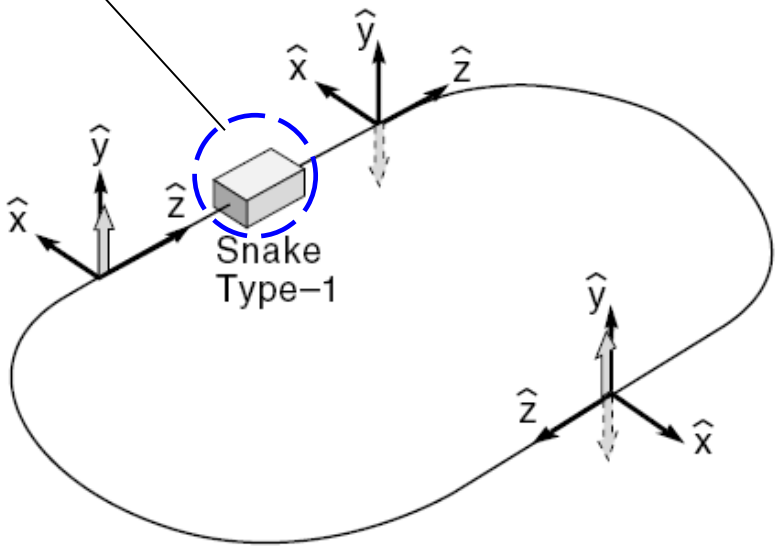
he Siberian snake can help.



The snake rotates the spin 180°



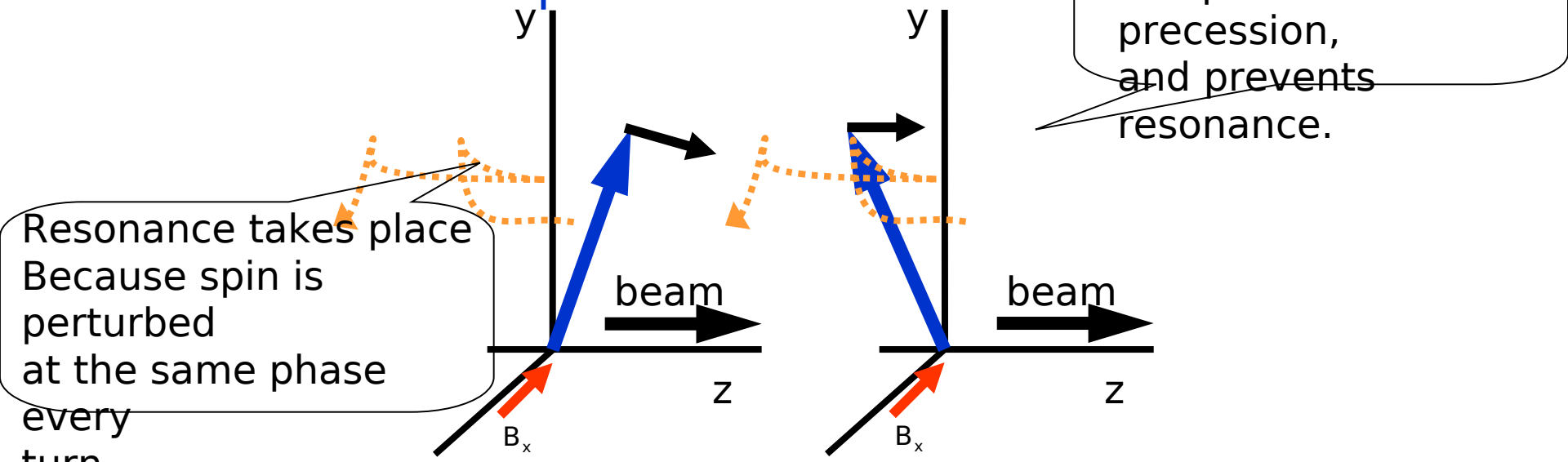
Mei Bai's 423rd Brookhaven Lecture



Alex Chao lectures (2002)

How to preserve polarization using Siberian snake(s)

- Break the coherent build-up of the perturbations on the spin vector



The snake changes this phase of precession, and prevents resonance.

Resonance takes place Because spin is perturbed at the same phase every turn.

Snakes in the AGS

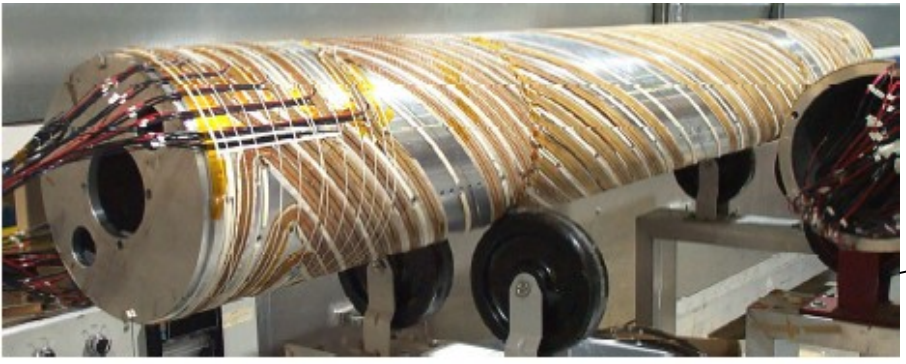


Figure 1: Helical windings of the super-conducting strong Siberian snake for the AGS

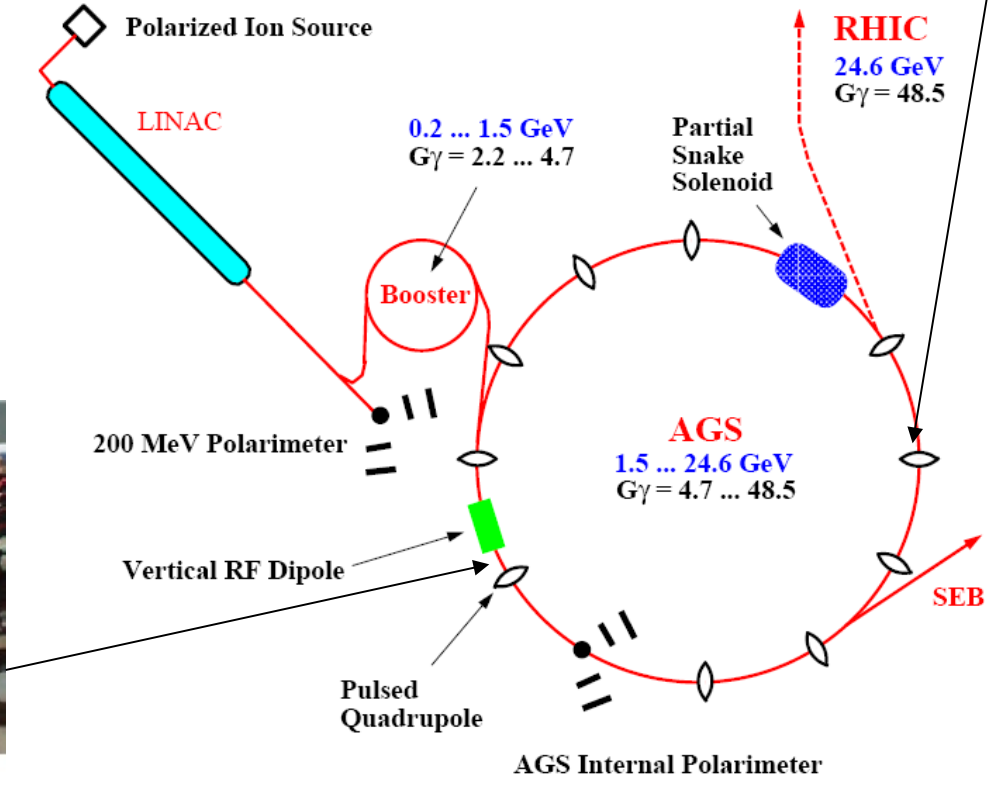
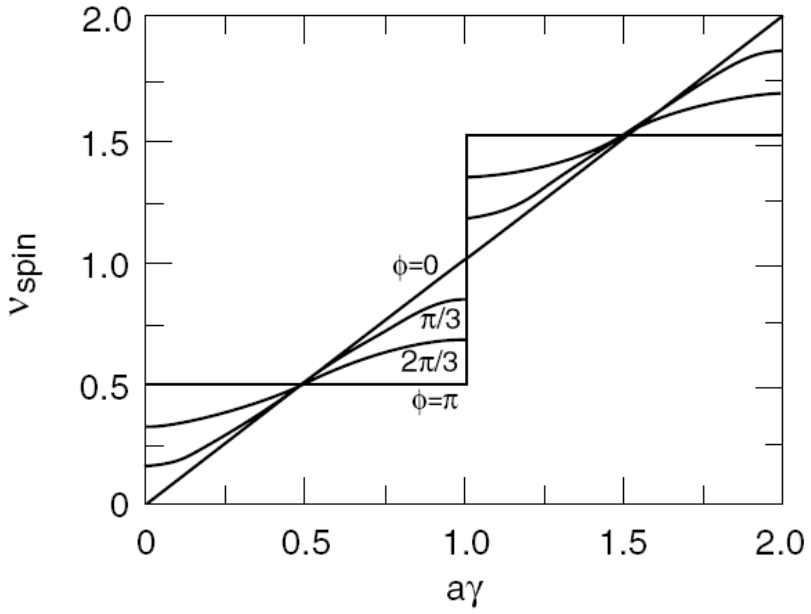


Figure 2.1: Schematic of the AGS complex for polarized proton acceleration.

Partial snakes

- AGS is a 200 m ring, too small for a full Siberian snake.
- Two partial snakes are installed.
- A partial snake rotates spin by less than 180^{o}.
- It changes the spin tune slightly so that it can never be an integer.
- This avoids resonances due to magnet misalignments.



(or energy)

Alex Chao lectures (2002)

The paper: Optimising the snakes

- Two partial snakes are installed in the AGS - one warm, one cold (superconducting).
- A partial snake rotates spin by only a few degrees.
- Strength of the cold snake is adjusted to optimise the spin polarisation.
- Protons are injected at 85% polarisation. After acceleration, 65% is preserved by the snakes.